I. C. 6973

NOVEMBER 1937

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

ANNUAL REPORT OF THE MINING DIVISION FOR THE FISCAL YEAR 1937

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CHAS. F. JACKSON

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

ANNUAL REPORT OF THE MINING DIVISION FOR THE FISCAL YEAR 1937[1]

By Chas. F. Jackson[2]

INTRODUCTION

The work of the Mining Division is divided among seven sections, each in charge of a supervising engineer, as follows:

1. Metal-mining methods section, the supervising engineer of which is also supervising engineer of the Southwest Experiment Station at Tucson, Ariz.
2. Metal-mining research section.
3. Nonmetal-mining section.
4. Coal-mining section.
5. Mine-ventilation section.
6. Mineral-industries survey section.
7. Electrical section.

The names of the sections indicate broadly the fields covered by each, and in the following pages the objectives and type of work of each section will be summarized briefly and their active problems listed. The work done during the fiscal year 1937 will also be summarized.

1. Metal-Mining Methods Section

Metal-Mining Methods in Western States. - For some years the work of this section has been devoted largely to a study of mining methods, practices, and costs in the Western States made in cooperation with the managers and other operating officials of the principal mines. The characteristics of the ore deposits and the nature of the ores, the mining methods and practices, and the operating costs (expressed both in dollars and units of labor, materials, power, and supplies) at each mine have been tabulated in accordance with an outline and published as information circulars. The object of the study was to provide comparable data covering a wide range of conditions upon which to base an analytical study of mining methods and practices from the operators' viewpoint. During the fiscal year 1937 the following publications were issued:

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[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 6973."

[2] Chief engineer, Mining Division, Bureau of Mines.

Inf. Circ. 6940 - Mining Methods at the Carson Hill Mine, Calaveras County, Calif. 15 pp.
Inf. Circ. 6945 - Mining and Milling Methods at the Pilgrim Mine, Chloride, Ariz. 18 pp.
Inf. Circ. 6947 - Mining and Milling Methods and Costs at the Golden Messenger Mine of the United Gold Mines Corporation, York, Mont. 14 pp.

In addition the following manuscripts were completed, received at the Washington Office, and await publication.

Inf. Circ. ____ - Mining and Milling Methods and Costs of the St. Joe Mining & Milling Co., Boulder, Colo.
Inf. Circ. 6950 - Mining and Reduction Methods and Costs at the Oceanic Quicksilver Mine, Cambria, San Luis Obispo County, Calif. 13 pp.
Inf. Circ. ____ - Placer Operations of Humphreys Gold Corporation, Clear Creek, Colo.
Inf. Circ. ____ - Mining Methods and Costs of the Mt. Isa Mines, Ltd., Mount Isa, Queensland, Australia.
Inf. Circ. ____ - Mining Methods and Costs of the Quartz Hill Mining Co., Dewey, Mont.
Inf. Circ. 6960 - Sampling and Testing of a Gold-Scheelite Placer Deposit in the Mojave Desert, Kern and San Bernardino Counties, Calif., 18 pp.

The investigation is a continuous one, and it is planned, in addition to publishing reports from time to time on operations not previously described, to prepare supplements covering significant changes in practices at mines described in circulars issued some years ago.

Metal-Mining Methods and Costs Summaries. - These summaries embrace studies of the principal mining methods and different phases of mine operation, such as underground transportation, chute gates, ore pockets, sampling and estimation of ore deposits, shaft sinking, waste filling of stopes, sampling and exploration, placer mining, methods and costs of equipping and developing prospects, leasing systems, drifting and crosscutting, aerial-tramway construction and operation. They also include studies of the mining of different types of ore such as gold mining, lead and zinc mining and copper mining. The studies are based largely upon the data contained in circulars dealing with operations at individual mines and upon past operating experience of Bureau engineers, but also include special field investigations to round out these data. During the fiscal year 1937 the following publications in this series were issued:

Inf. Circ. 6898 - Costs of Trucking and Packing Ore in Western Gold-Mining Districts. 17 pp.
Inf. Circ. 6923 - Shaft Sinking with a Shot-Drill, Idaho-Maryland Mine, Grass Valley, Calif. 10 pp.
Inf. Circ. 6943 - Design of Small Wooden Head Frames. 37 pp.

In addition, the following manuscripts were completed, received at the Washington Office, and await publication:

Bull. ____ - Copper Mining in North America.
Inf. Circ. 6948 - Aerial Tramways in the Metal-Mining Industry, Part I., 32 pp.

Active problems under investigation include:

Placer Mining of Gold.
Development, Equipment, and Operation of Small Gold Mines.
Aerial Tramways in the Metal-Mining Industry, Part II. Methods and Costs of Operation.
Mine Drainage and Pumping.

The broad objective of the metal-mining investigations is to acquaint mine operators and engineers generally with improved methods and practices developed locally, to the end that mining technology in this country be raised to the highest possible efficiency. This is a matter of national importance in view of the rapid depletion of our higher-grade ores which necessitates mining ores of progressively lower grade to satisfy our requirements for metals. Large reserves of higher-grade ores remain in certain foreign countries where labor costs are low, and improved technology and efficiency must be relied upon to meet foreign competition.

A number of specific instances have been brought to our attention in which decided improvements in methods and costs have been attained as a result of these publications. As members of the division have received many requests from mine operators for more publications of this type, it may safely be inferred that the desired results are being obtained.

Milling Methods and Costs, Western States. - This study embraces milling methods and costs and the preparation for publication of manuscripts covering studies at individual ore-dressing plants. The procedure and objectives are the same, with respect to milling operations, as those described for mining operations.

The following publications were issued during the year:

Inf. Circ. 6900 - Mining and Milling Methods and Costs at the Yellow Aster Mine, Randsburg, Calif. 21 pp.
Inf. Circ. 6945 - Mining and Milling Methods and Costs at the Pilgrim Mine, Chloride, Ariz. 18 pp.
Inf. Circ. 6947 - Mining and Milling Methods and Costs at the Golden Messenger Mine of the United Gold Mines Corporation, York, Mont. 14 pp.

In addition the following manuscript was completed, received at the Washington Office, and awaits publication.

Inf. Circ. ____ - Mining and Milling Methods and Costs of the St. Joe Mining & Milling Co., Boulder County, Colo.

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Milling Methods and Costs Summaries. - These studies embrace special phases of mill operation, the milling of ores of different types, and related problems and the preparation of reports thereon. They are based partly upon data contained in circulars dealing with practices at individual mills and partly upon special field investigation. During the year the following publication was issued:

Inf. Circ. 6926- Open Schedules for Gold and Silver Ores and Concentrates at Western Custom Smelters. 25 pp.

Part of the Mineral Industries Survey Supplementing the Work of the Mineral Industries Survey Section.- This work includes field surveys and preparation of reports for publication on mining and milling practices and costs in various western mining districts; data on known ore occurrences therein; haulage, freight, and ore-treatment costs; and general geological data. It also includes assistance to small-scale operators and prospectors who are obviously financially unable to employ competent technical advice. Such assistance is granted only upon request. If it appears that the operator can afford to employ needed technical assistance, the engineers of the Bureau refer the operator to competent consultants, the policy being to recommend at least three if possible, and preferably men from the district or State in which the property is located.

Publications issued during the year were:

Inf. Circ. 6901 - Gold Mining and Milling in the Black Mountains, Western Mohave County, Ariz. 59 pp.
Inf. Circ. 6902 - Reconnaissance of Mining Districts in Pershing County, Nev. 57 pp.
Inf. Circ. 6905 - Gold Mining and Milling in the Black Canyon Area, Yavapai County, Ariz. 51 pp.
Inf. Circ. 6941 - Reconnaissance of Mining Districts in Mineral County, Nev. 79 pp.
University of Nevada Bulletin, vol. 30, no. 4, Placer Mining in Nevada, written by William O. Vanderburg, of the Mining Division, and published by the University of Nevada. 180 pp.

In addition the following manuscripts were completed, received at the Washington Office, and await publication.

Inf. Circ. 6964 - Reconnaissance of Mining Districts in Clark County, Nev. 81 pp.
Inf. Circ. ____ - Gold Lode Mining in the Tobacco Root Mountains, Madison County, Mont.
Inf. Circ. ____ - Gold Mining in New Mexico.
Inf. Circ. ____ - Mining and Milling in the Searchlight and Eldorado Districts, Clark County, Nev.
Inf. Circ. ____ - Mining and Milling in the Wickenburg Area, Arizona.

During May 1937, field work was started to gather data for a series of circulars and ultimately a bulletin on Placer Mining in Idaho, in cooperation with the State Bureau of Mines and Geology. Two engineers have been assigned to this work, the completion of which will require at least two field seasons.

In June 1937, 100 tons of nickel-bearing rock were mined from a peridotite dike in the Copper King district of the Boulder Dam area of Nevada for use of the Metallurgical Division in research aimed at developing methods for recovering nickel from the low-grade ores of that district.

Forms for recording data on mining properties were devised and printed. These are to be filled out by field engineers when visiting mining properties and are to be prepared in triplicate to constitute a permanent file of pertinent information, one copy to be held in the preparing engineer's files, one in the files of the supervising engineer, and one in the files of the chief engineer of the Mining Division.

2. Metal-Mining Research Section

The work of this section is of two types: (1) Investigations of mining and milling methods and costs, which are of the same nature as those conducted by the metal-mining methods section except that they cover studies of and reports on operations in the Central and Eastern States; and (2) research in fundamental mining engineering problems.

Publications issued during the year under the first general classification were as follows:

Inf. Circ. 6914 - Mining and Milling Methods and Costs, Hog Mountain Gold Mining & Milling Co., Alexander City, Ala. 23 pp.
Inf. Circ. 6908 - Underground Mill at the Doyle Mine, Shullsburg, Wis. 4 pp.

Applications of Compressed Air in Mining. - This study was started in 1936 and has for its object correlation, discussion, and analyses of available information on different types of compressors; transmission of compressed air; different applications of compressed air in mining operations; advantages and disadvantages of compressed air compared to electrical, steam, and gas-engine drive for mining equipment; and preparation of a bulletin on the subject. A study of the literature and special field investigations are involved.

Steel shop Practice at Metal Mines. - This investigation is to cover a study of steel-shop lay-outs, drill-steel sharpening and heat-treating practices, methods of handling steel, etc. The following publication was issued during the year:

Inf. Circ. 6907 - Hot Milling of Rock-Drill Bits at the Mines of the Vinegar Hill Zinc Co., Platteville, Wis. 2 pp.

Signal Systems in Metal Mines. - This investigation involves gathering of data on installation, operating, and maintenance costs for different types of shaft signal systems, their relative dependability, the particular field of application of each type, and the preparation of a report covering the investigations. Considerable data were gathered during 1936, but no publications have been issued as yet. The following manuscript was completed and is awaiting printing:

Inf. Circ. ____ - Electric Signaling System, Ross Shaft, Homestake Mining Co.

The second type of work of the research section embraces several investigations, as follows:

Use of Detachable Rock-Drill Bits. - This study covers the gathering of field and shop data on performance and costs of drilling with detachable bits compared to standard bits forged on the steels; tests of detachable bits of different types and different steel compositions at the Mount Weather testing adit; analyses of data; study of adaptability of bits of different types and compositions to drilling different kinds of rocks; and preparation of reports for publication.

During the latter part of 1935 and 1936 about 35 metal mines where detachable bits were being employed were visited for the purpose of gathering operating data and discussing the subject with mine operators. Preliminary reports were published during 1937, as follows:

Inf. Circ. 6911 - Progress Report 2 on Investigation of Detachable Rock-Drill Bits. 20 pp.
Inf. Circ. 6936 - Progress Report 3 on Investigation of Detachable Rock-Drill Bits. 27 pp.
In addition, Progress Report 4 was completed and awaits publication.

Reports 1 to 4, inclusive, comprise data on practices and costs at 5 to 10 different mines. It is planned to summarize and analyze the data from all the mines later and to publish additional reports on tests being made at the Mount Weather testing adit as results are obtained that will contribute to the knowledge of the subject.

During the year arrangements were made with manufacturers of alloy steels and with bit manufacturers for making alloy-steel bits and rods. A number of alloy bits were delivered and tested by our engineers for Rockwell hardness preliminary to making actual drilling tests at the Mount Weather testing adit. Hard-surfaced ("stellited") bits were also made up and are ready for testing.

Determination of Stresses in Rocks by Use of Seismometers and Supersensitive Microphones. - The purpose of this study is to devise and conduct laboratory and field tests with apparatus by the use of which it may be possible to determine conditions leading to failure of rock and coal pillars and arches before ordinary indications, such as settlement, spalling, cracking, etc., are apparent. If apparatus of this kind can be developed it should assist materially in determining the safe size of mine openings (rooms and stopes) and the minimum

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safe pillar sizes in different mines or sections of the same mine and should help in solving roof-control problems and in forewarning against accidents from caving and falls of ground.

Preliminary experiments with the Bureau of Mines type of seismometer showed that both amplitude and frequency of induced vibrations in rocks under test varied with change of pressure, although the few tests made do not as yet indicate any law regarding the relationship of vibration characteristics to pressure. It was found that the curves (pressure against amplitude of vibration and pressure against frequency of vibration) probably vary with the kind of rock and with the arrangement of the recording devices but that in every instance amplitude and frequency curves break sharply at about the same pressure in each test, which may indicate a critical condition of the rock. Tests with crystal pick-up and cathoderay recording apparatus show changes in the patterns of 1,800-cycle waves with increased pressure, which may be significant.

Operation of Mount Weather (Va.) Testing Adit. - This work comprises driving an adit and other workings therefrom on Government-owned land at Mount Weather, Va., to provide a testing laboratory in which to investigate numerous fundamental mining problems under simulated mine-scale conditions but in which interfering variables can be eliminated or controlled. The rock formation consists of basaltic lava flows, which in places are largely altered to epidote. The unaltered lava is very hard, contains 10 percent and more of free silica, and can be drilled at the rate of about 6 inches per minute with sharp steel and 3-1/2-inch drifter machines operating on 90 to 100 pounds air pressure.

The altered rock is softer (some is very soft), and some of the ground is seamed and shattered. Various drilling conditions are therefore presented, which is a desirable feature for test work.

Work was begun late in September 1936. By the end of the year the site had been cleared, roads cleared and repaired, a 230-foot air compressor installed and properly housed, an office set up in an old farmhouse close to the adit, rock-drilling equipment assembled and placed in service, pipe lines laid, and 300 feet of 7- by 8-foot adit driven, timbered for 120 feet, and tracked. The direct cost of driving the first 175 feet was $8.54 per foot.

Experimental work in cooperation with other divisions of the Technologic Branch of the Bureau and with the Health and Safety Branch was initiated during the year.

Effect of Bit Sharpness on Dustiness during Wet Drilling. - Preliminary tests indicated that more dust entered the atmosphere when drilling was done with sharp bits than when it was done with dull bits, both on a time and on a footage basis. This probably is due to the fact that considerably more water enters the hole per cubic inch of rock drilled out when dull bits are used. The tests also showed that the quantity of dust is several times as great in collaring and drilling the first foot or two of hole as in drilling the remainder of the hole. Inside calipers for measuring the diameters of drill holes were designed and constructed and proved to be practicable. No publications have been issued as yet.

Investigation of Gases Liberated in Blasting under Controlled Mine Conditions. - Preliminary tests were made in May 1937; 60-percent gelatin dynamite and 40-percent gelatin dynamite were employed, respectively, in each of two standard tunnel rounds, about 50 pounds being used in each. Appreciable percentages of CO, and CO_2 and oxides of nitrogen were found in each test at intervals of 10 minutes to 12 hours after firing. No publications have yet been issued by the mining division on this subject.

3. Nonmetal-Mining Section

The nonmetal-mining section concerns itself with the investigation of the mining and preparation of industrial minerals and the publication of reports thereon. The work is designed to cover the field of nonmetal mining in a manner similar to that in which the metal-mining methods and metal-mining research sections cover the metallic mining field.

Methods and Costs of Mining and Preparation of Nonmetallic Minerals. - This investigation includes studies of mining, quarrying, and preparation of nonmetallic minerals at individual pits and plants and preparation of reports thereon. The object is to aid, through dissemination of information on details of practice, improvement in technology, efficiency, and elimination of waste. Publications issued during the fiscal year 1937 were as follows:

Inf. Circ. 6889 - Mining and Grinding Methods and Costs at the Camp Bro. Co. Shale Pit, Mogadore, Ohio, 11 pp.
Inf. Circ. 6910 - Mining, Treatment, Methods, and Costs at the Gifford Hill & Co. Sand and Gravel Plant at Hoot Spur near Texarkana, Tex. 11 pp.
Inf. Circ. 6912 - Quarrying and Crushing Methods and Costs at the Avon Mountain Trap-Rock Quarry of the Atlas Sand, Gravel & Stone Co., West Hartford, Conn. 7 pp.
Inf. Circ. 6913 - Mining and Grinding Methods and Costs at the Clay City Pipe Co. Clay Mine, Uhrichsville, Ohio, 16 pp.
Inf. Circ. 6920 - Quarrying and Crushing Methods and Costs at the Plainville, Conn., Trap-Rock Quarry of the New Haven Trap Rock Co. 23 pp.
Inf. Circ. 6921 - Mining and Grinding Methods and Costs at the Dennison Sewer Pipe Co. Clay Mine, Dennison, Ohio. 16 pp.
Inf. Circ. 6929 - Mining and Grinding Methods and Costs at the Evans Pipe Co. Clay Mine, Uhrichsville, Ohio, 18 pp.
Inf. Circ. 6937 - Mining and Milling Methods and Costs at the Glass Sand Plant of P. J. Weisel, Inc., Corona, Calif. 16 pp.

Manuscripts completed and awaiting publication are as follows:

Inf. Circ. ____ - Mining and Grinding Methods and Costs at the Malvern Clay Mine, Malvern, Ohio.
Inf. Circ. ____ - Methods and Costs of Mining and Crushing Gypsum at the Mine of the Victor Plaster Co., Victor, N. Y.
Inf. Circ. 6971 - Methods and Costs of Mining and Crushing Gypsum at the Mine of the Ebsary Gypsum Co., Wheatland, N. Y., 19 pp.

Methods and Costs of Mining and Preparation of Nonmetallic Minerals, Summaries.- This study comprises investigations and reports summarizing special phases of the mining and preparation of nonmetallic minerals, the different nonmetallic minerals and commodities, the operations entering into mining and preparation, and the preparation of special products derived from nonmetallic minerals. These investigations are based partly upon data contained in reports of operations at individual plants and partly upon special field investigations. During the year 28 mineral-wool plants were inspected and notes taken as the basis for a report on the mineral-wool industry.

Another phase of the work of this section is fundamental engineering research under a problem entitled, "Research in Mining and Quarrying Nonmetallic Minerals", which includes the following:

Relation Between Size Gradation of Quarry-Run and Primary-Crusher Products.- This study is being conducted to determine the screen sizes produced by primary crushers of various types with rocks of different kinds and various feed sizes. Little is known on the subject, although it is one of importance in certain nonmetallic industries.

Library research was followed by screen-sizing tests at four quarries. The crushed-stone producer desires to prepare a market product of coarse aggregate with a maximum percentage of cubical particles and a minimum of fines smaller than $\frac{1}{2}$ inch. The study is designed to determine the type of crusher best adapted to prepare the desired product from different kinds of rocks. No definite conclusions have been reached, but differences have been found among products from gyratory, jaw, and hammer mills. No publications were issued, but the following manuscript was completed: "Primary Crushing Progress Report No. 2."

Report no. 1, based on earlier tests, was partly revised but is not yet ready for publication.

Earth and Air Vibrations Caused by Blasting in Quarries and Mines. - The purpose of this work is to determine, by the use of seismographs and recording apparatus developed by the Bureau of Mines' staff, the characteristics (amplitude, frequency, and rate of propagation) of vibratory waves produced by blasting, both fundamentally and in relation to the transmitting media, and their effects upon artificial structures. The Bureau apparatus measures the amplitude of vibrations in ten-thousandths of an inch.

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During the year a complete field outfit was assembled in a specially constructed truck, and observations were made in 19 quarries in the Eastern and Southern States on earth vibrations caused by shots ranging from 42 to 20,000 pounds of explosive per shot. The resulting data were compiled and correlated, and confidential reports were sent to the cooperating quarry companies concerned. As a result of this work considerable new information has been gained concerning the characteristics of earth vibrations caused by blasting operations and the influence upon them of structural changes in the ground, and improved field technique has been developed. It has been found, for example, that loose overburden vibrates as a mass at its own frequency and that the vibrations of the mass may differ considerably in frequency, amplitude, and speed of propagation from those in the underlying solid rock strata. Considerable work was done on the calibration of recording instruments, and a number of improvements were made that will make for still greater accuracy of future measurements.

One publication was issued:

R. I. 3319 - "Earth Vibrations caused by Quarry Blasting." 19 pp.
Another more comprehensive report on the same subject was completed and is ready for printing.
R. I. ____ - "Earth Vibrations from Quarry Blasting, Progress Report No. 1."
In addition, confidential reports on the tests were forwarded to the operators of quarries in which tests were made.

Measurements of vibrations set up in a stucco dwelling by various causes were made in cooperation with the National Bureau of Standards. It was found that a person walking or slamming a door in the house caused vibrations of greater amplitude than those induced by an unbalanced motor running in the house or by heavy trucks passing in the street. A paper entitled, "Measurement of Mechanically Induced Vibrations on a Stucco Residence," was prepared with a view to its presentation at a meeting of the American Institute of Mining and Metallurgical Engineers.

About 120 tests were made in an underground limestone quarry in Pennsylvania to determine what, if any, were the effects of blasting with explosives of different types, fired under different conditions and in varying quantities, upon roof failure. The conclusions were that vibrations from blasting had little if any effect in causing falls of roof.

Among the conclusions to date as a result of the vibrational work are:

1. Vibrations received on outcrops of solid rock have higher frequencies and lower amplitudes than those received on overburden.
2. Vibrations received on overburden have a wide range of frequencies.
3. Vibrations received on floors and walls of buildings have moderately low frequencies and high amplitudes.
4. Vibrations received on glacial fill or sand, clay, and gravel mixtures are of low frequency and comparatively high amplitude.

5. Vibrations from quarry blasts are of higher frequency and lower amplitudes than those from earthquakes.

Arrangements were made near the end of the year for destructive vibrational tests on buildings in Indiana and Kentucky which are about to be demolished.

4. Coal-Mining Section

The work of the coal-mining section, which was reestablished late in 1935, is designed to cover coal-mining in much the manner and with the same general objectives that the metal- and nonmetal-mining sections cover their particular fields. Although the present staff of two engineers is inadequate to handle a subject as large and varied as coal mining, the results of the work in 1937 were not without value.

Coal-Mining Methods and Costs. - Studies are made of coal-mining methods, practices, and costs at individual mines or groups of mines, and reports thereon are prepared for publication. The purpose is to acquaint coal operators generally with improvements in practice developed locally with a view to increasing operating efficiency and promoting safety and conservation in mining. One publication was issued during the year:

Inf. Circ. 6928 - Mining Methods Used in the Grundy Coal Field of Buchanan County, Va., 43 pp.

Nine mines in this field were visited and studied, and operating data thereon were compiled.

Coal-Mining Methods and Costs - Summaries. - This involves studies and preparation of reports for publication dealing with special phases of coal mining, based upon earlier studies and publications and upon special field investigations.

A manuscript entitled "Shaft and Slope-Bottom Lay-Outs at Coal Mines" was completed and is ready for publication as an Information Circular. Field work comprised inspection and study of the operations and data on lay-outs at 21 bituminous coal mines.

Field work was completed, and a manuscript was submitted for publication as an Information Circular on "Some Aspects of Strip Mining of Bituminous Coal in Central and South Central States." This paper is based upon studies of 18 strip-mining operations and operating data thereon and upon data supplied by manufacturers of stripping equipment.

Field work was started the latter part of the year on concentrated, multiple-shift, mechanized coal mining. Operations at mines in Wyoming, West Virginia, and Kentucky were inspected. The investigations are designed to lay the ground work for an analysis of methods, practices, distribution of labor, and effects of mechanization upon efficiency, conservation (percent recovery of coal), safety in working, and roof control.

5. Mine-Ventilation Section

This section has been engaged for some years in a study of mine-ventilation problems, mine-ventilation surveys, and determination of ventilation factors. The work has covered both coal and metal mining. Most of 1937 was spent on a study of the origin of mine fires in the anthracite region of Pennsylvania. A better idea of the work of the section is obtained from a number of the principal publications issued in preceding years which are listed below:

Bull. 285 - Coal-Mine Ventilation Factors. 1929. 106 pp., 47 figs., 39 tables.
Bull. 330 - Ventilation of the Large Coper Mines of Arizona. 1931. 145 pp., 42 figs., 17 tables.
T. P. 516 - Natural Ventilation of Michigan Copper Mines. 1932. 40 pp., 5 figs., 6 tables.
Bull. 385 - Engineering Factors in the Ventilation of Metal Mines. 1935. 196 pp., 68 figs., 4 tables.
Inf. Circ. 6382 - Mine Ventilation in the Coeur d'Alene District, Idaho. 1931. 37 pp., 5 figs.
Inf. Circ. 6585 - Economic Size of Metal-Mine Airways. 1932. 21 pp. 4 figs.
Inf. Circ. 6663 - Pressure Losses Due to Bends and Area Changes in Mine Airways. 1932. 34 pp., 12 figs., 1 table.

The active problems of this section are as follows:

Mine-Ventilation Surveys. - This study includes an investigation in the field of conditions at individual mines, confidential reports and recommendations to the mine operators, and preparation of reports on mine-ventilation methods and systems at individual mines or groups of mines for publication. One report was completed during the year and now awaits publication:

Inf. Circ. ____ - Ventilation at the Anthracite Collieries of the Northern Pennsylvania Field.

Mine-Ventilation Summaries. - This study involves preparation of papers for publication on the various phases of mine ventilation.

Mine-Ventilation Research. - The investigation includes study and determination of fundamental factors in connection with mine ventilation and of special problems.

Study of Origin of Mine Fires in the Anthracite Mines of Pennsylvania. - The purpose of this investigation is to determine from mine records of past and present mine fires and from a study of mine atmospheres, coal composition, ventilating conditions, etc., the origin of mine fires in this region and, if possible, to derive new methods for their prevention and control. This is a cooperative investigation participated in by the Mining, Explosives, and Coal Divisions of the Bureau, the Health and Safety Branch of the Bureau, and one of the largest producing companies in the region.

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During the year records of about 170 mine fires were studied, underground conditions were investigated, and numerous discussions were held with operating officials at the mines. A résumé of the work done up to November 27, 1936, was prepared on various phases of the investigation, as follows: A. Abstract of literature on mine fires. B. Survey and investigation of mine-fire records and tracing of probable cause of each fire, methods used in fighting fires, analyses of mine-fire atmospheres, analyses of coal and inflammable materials found underground (Coal Division), present status of mine fires, and influence of mining methods and ventilation on fires. C. Procedures for preventing fires. D. Methods of extinguishing fires.

A final confidential report on results of the investigations to date was forwarded to the officials of the cooperating company in June 1937 and included recommendations for prevention of fires and for further studies. Among the conclusions reached were:

1. The largest number of fires are caused by explosives used in mining. Two other important causes are open (surface) fires and recurrences of old fires. Gas explosions usually have not caused major fires except under abnormal gas conditions.
2. It is roughly estimated that fires in the anthracite mines of Pennsylvania have to date cost the operators at least $50,000,000 in terms of present-day values.
3. Many fires have recurred years after they were thought to have been extinguished. A hitherto unexpected source of recurrences may be accumulations of hydrogen, which laboratory work shows may be derived from anthracite coal at certain temperatures.
4. Most fires have been extinguished by direct attack in a very short time and at slight expense.
5. Numerous recurrences indicate the erratic success of indirect methods for combatting fires in broken ground. Sealing has generally been unsuccessful except as a method of retarding spread of fires.

Air-Conditioning of Mines. - This investigation includes a study of air-conditioning principles, methods, and practices and of air-conditioning apparatus with reference to its application to air-conditioning of mines.

Available data were compiled and studied and will be incorporated later in a publication on the application of mechanical refrigeration to mines. The entire question of air-conditioning of mines is based upon temperature changes in mine air currents, a subject so complex that experience and direct observation only can be relied upon until mathematical solutions are developed.

6. Mineral-Industries Survey Section

This section was established to carry on an investigation provided for in the Interior Department appropriation bill for the fiscal year 1936 and continued in the 1937 bill. The bill provided for a "Mineral Inventory, and Technical Aid to Small Operators." Because the metal-mining methods section was already well-organized and because it was desired to cover the large field more rapidly, the work has so far been carried on jointly by that section and the mineral-industries survey section. Publications issued during 1937 as a result of the work of the former have already been listed under "Metal-Mining Methods Section." These describe districts in which most of the mining operations are small and widely scattered, whereas the work of the mineral-industries survey section has comprised an intensive study of districts which are restricted in area but in which there are one or more outstanding mining operations or recent important new discoveries, or which reveal special situations of broad significance such as the successful rejuvenation of an old district.

During the year the following publication was prepared by the section:

Inf. Circ. 6931 - Mineral Industries Survey of the United States: California, Kern County, Mojave District - The Golden Queen and Other Mines of the Mojave District, California. 42 pp, 13 figs.

Several months were spent in the southern Mother Lode area, comprising Calaveras, Tuolumne, and Mariposa Counties, Calif. The 1937 field season began with a return to this area for the purpose of completing the survey and a report for publication. The work in Calaveras County is about 60 percent completed, and a report thereon was partly completed at the end of the year.

7. Electrical Section

The electrical section has charge of investigations relating to the safe use of electrical equipment in and about mines and of flame-safety lamps and gas-indicating devices. A large percentage of the work for 25 years has been the testing of electrical equipment according to a number of published schedules devised to enhance safety in the use of such equipment in mining. This testing has resulted in thousands of units of electrical equipment bearing the Government safety label being placed in mines of the United States. These labels guarantee that the equipment has been tested and meets certain minimum requirements for safety.

The following schedules are in force:

Schedule 2D. Explosion-Proof Mine Equipment.
Schedule 6C. Permissible Electric Cap Lamps.
Schedule 7C. Flame Safety Lamps.
Schedule 8C. Portable Methane Detectors.
Schedule 9A. Procedure for Establishing a List of Permissible Telephones for Use in Coal Mines.
Schedule 10B. Miscellaneous Portable and Semiportable Electric Mine Lamps.
Schedule 11A. Permissible Electric Flashlights.
Schedule 12B. Single-Shot Blasting Units.
Schedule 16A. Multiple-Shot Blasting Units.

Schedule 2D. - During the fiscal year 1937, 26 complete units composed of 98 explosion-proof compartments were approved; these units comprised 9 mining (coal-cutting) machines, 13 loading machines and conveyors, 1 drill, and 3 storage-battery locomotives. There are now 270 units on the approved list and during the year over 600 changes in designs of these machines were examined and approved. As the number of approved machines increases, the work of examining changes in design thereof increases proportionately. Approvals are granted only for complete machines. However, electrical accessories are examined and tested for suitability for use in complete units, thus facilitating exchange of explosion-tested compartments among manufacturers of machinery. During the year eight explosion-proof compartments including four motors, three starters, and one headlight were investigated and "suitability" reports issued.

Explosion Tests. - Not less than 10 and usually 20 to 80 tests are made to prove the effectiveness of a given design. During the year approximately 2,100 explosion tests were made on all types of equipment and accessories.

Schedules 6C and 10B - Electric Lamps. - During the year two electric lamps were added to the approved list.

Demonstration Equipment. - In March 1934, 10 glass-walled chambers, each containing a different arrangement of electrical circuits common in mines, were constructed to demonstrate how sparks may result and cause explosions of mixtures of methane and air. During the fiscal year at least 684 visitors witnessed demonstrations.

Committees. - The supervising engineer of the section was a member of four technical committees of national standing, and his work on these committees helps to keep the Bureau up-to-date with progress in electrical-engineering safety work.

Publications. - The following publications were issued during the year:

R. I. 3309 - Permissible Electrically Operated Air Compressors. 18 pp., 3 figs.
R. I. 3312 - The Improved Permissible Flame Safety Lamps. 10 pp., 2 figs.
R. I. 3326 - Permissible Electrically Operated Room Hoists. 12 pp., 4 figs.
R. I. 3327 - Behavior of Flame Safety Lamps in Mine Atmospheres Deficient in Oxygen. 6 pp., 2 figs.
R. I. 3345 - Permissible Electrically Operated Rock-Dust Distributors. 16 pp., 4 figs.

R. I. 3347 - The Importance of Adequate Voltage for Distribution Systems in Coal Mines. 12 pp., 3 figs.
Inf. Circ. 6904 - Milestones in Mine-Safety Legislation. 12 pp.
Inf. Circ. 6942 - List of Permissible Mine Equipment Approved to January 1, 1937. 23 pp.
Inf. Circ. 6944 - Bureau of Mines Apparatus for Demonstrating Electrical Ignition of Mine Gas. 5 pp., 1 fig.
Schedule 12B - Single-Shot Blasting Units. Requirements for Permissibility, Tests Made, and Fees Charged. 5 pp.
Schedule 16A - Multiple-Shot Blasting Units. Requirements for Permissibility, Tests Made, and Fees Charged. 9 pp.

8. Southwest Experiment Station, Tucson, Ariz.

On July 1, 1936, the Southwest Experiment Station was transferred to the Mining Division as most of the work of this station is under the supervising engineer of the Mining Methods Section of the Mining Division, who is also supervising engineer of the station. Three of the engineers of the section, with headquarters at other field offices, report to the supervising engineer. These offices are situated at Reno, Nev., Salt Lake City, Utah, and Moscow, Idaho, in order better to serve widely scattered areas and districts.

The metallurgical work at the station is an activity of the Metallurgical Division and is in charge of an engineer of that division who is acting supervising engineer of the Copper Metallurgy Section. The metallurgical research is done in cooperation with the University of Arizona, which supplies office and laboratory space to the Bureau and pays the salaries of two research fellows who work under Bureau of Mines direction. The metallurgical work was principally on three problems: "Recovery of Sulphur from Smelter Smoke", "Factors Governing the Flotation of Oxidized Minerals of Copper", and "Hall Process for Recovering Sulphur from Sulphide Flotation Concentrates." This work is described in detail in the annual report of the Metallurgical Division for the fiscal year 1937.

The activities of the Mining Division at the Station are described in more detail in a previous section of this report under the heading, "1. Metal-Mining Methods Section."